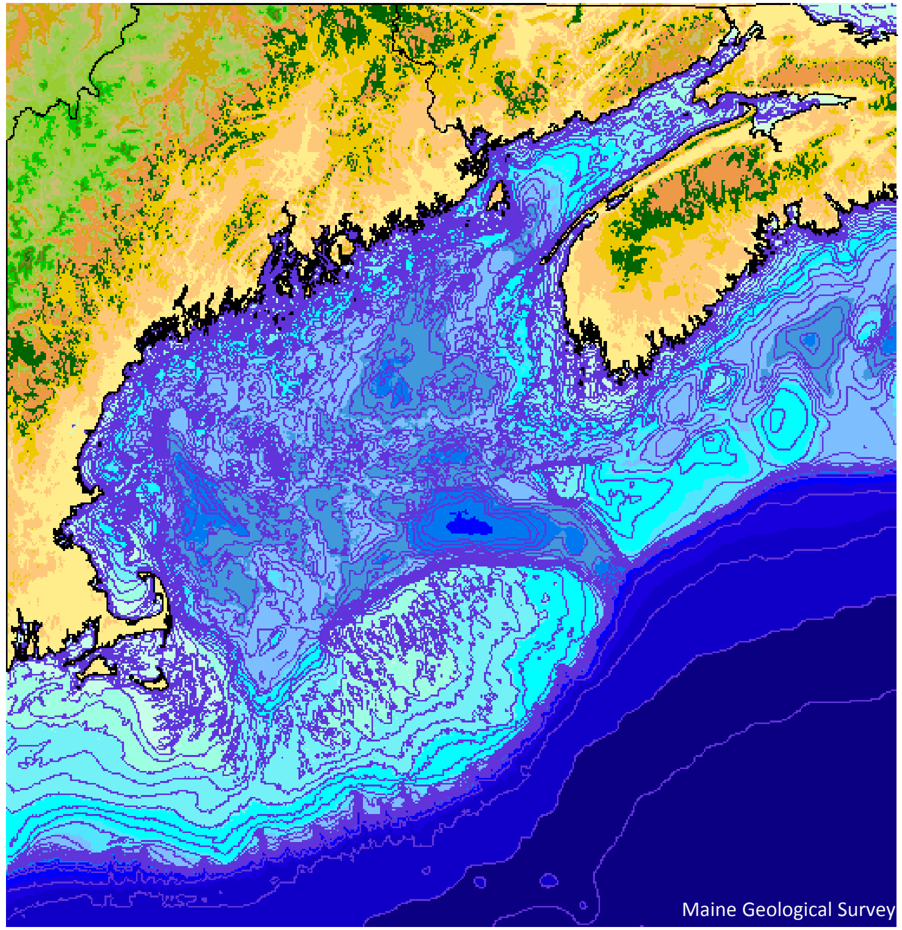
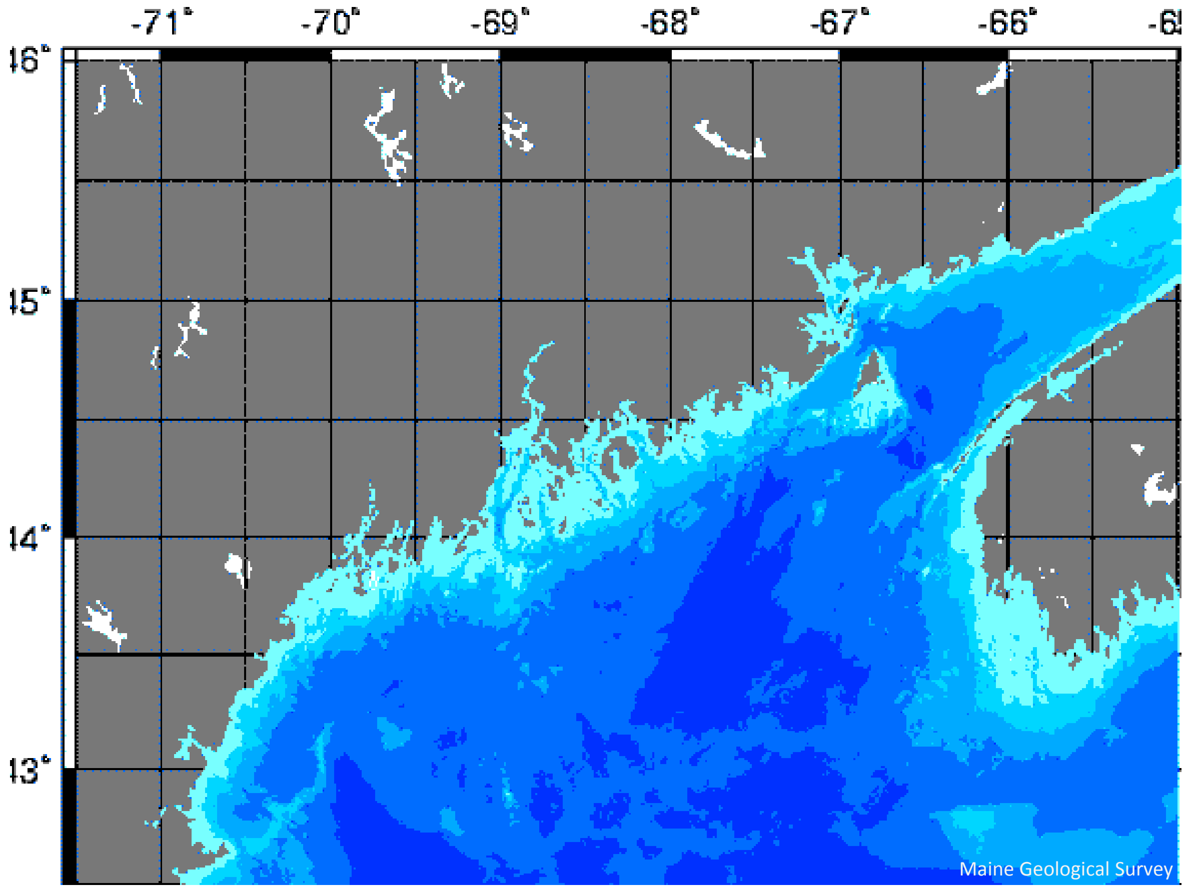
Virtual Tour
of
Maine's Coastal Marine Geology

Outline



The irregular coastline of Maine extends for 3478 miles of tidally-influenced shoreline along the Gulf of Maine. The Gulf of Maine is a semi-enclosed sea on the continental shelf of the eastern margin of the United States. The outer continental shelf is bounded by the shoals of Georges and Browns Banks that are bisected by the deep Northeast Channel.

Coastal Geography



The coast of Maine spans about 2 degrees of latitude and 4 degrees of longitude. The largest feature along the coast is Penobscot Bay. Numerous other bays and estuaries are also irregular in shape and have considerable relief in nearshore waters. Underwater canyons and shoals outline the relief of the bedrock structure offshore. Some 3500 islands lie along the Maine coast. Offshore, the State of Maine has jurisdiction over about 2800 square miles of submerged lands.

Seafloor Physiography

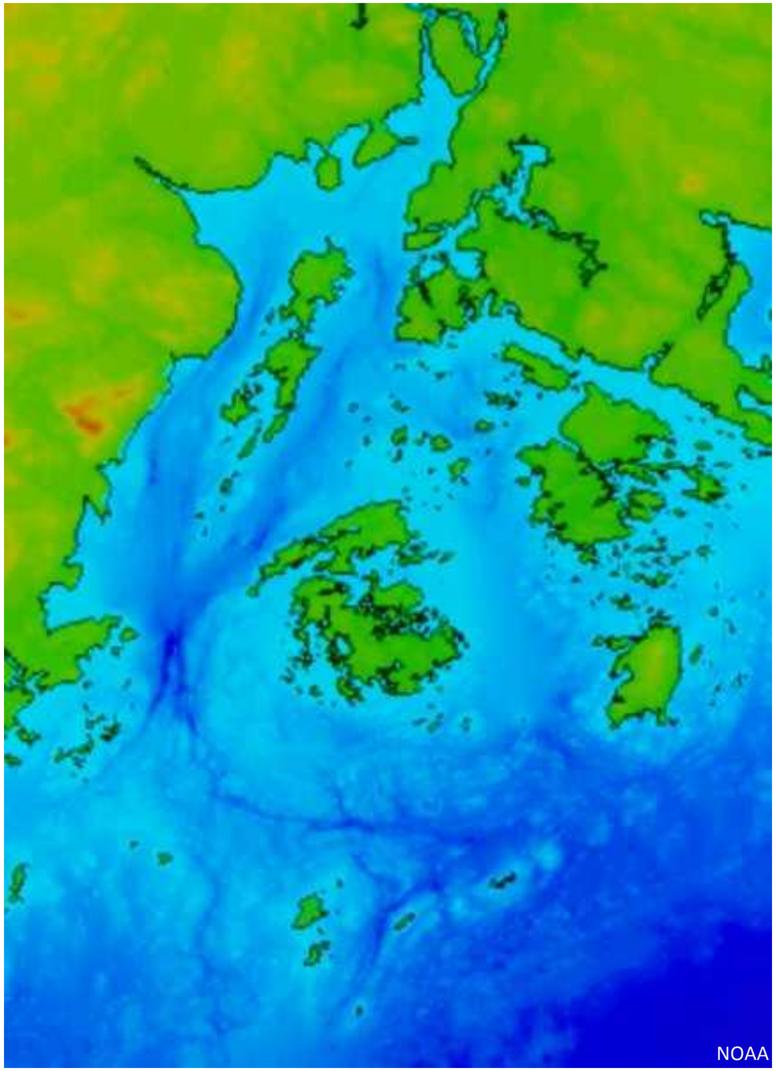


Image courtesy of NOAA

Seafloor relief generally mimics the topography of bedrock. In some areas irregular relief is subdued by accumulation of glacial sediments and postglacial marine mud over the bedrock surface. This image of Penobscot Bay illustrates how the large islands are simply the higher elevations of larger bedrock features that extend as much as 200 to 300 feet below the ocean surface. This large-scale structure influences both ocean circulation and the discharge of freshwater from the Penobscot River. Ocean currents moving into the bay and clockwise around North Haven and Vinalhaven Islands influence the ecology of the bay, including the dispersal and habitats of juvenile lobsters.

Nearshore Ramp

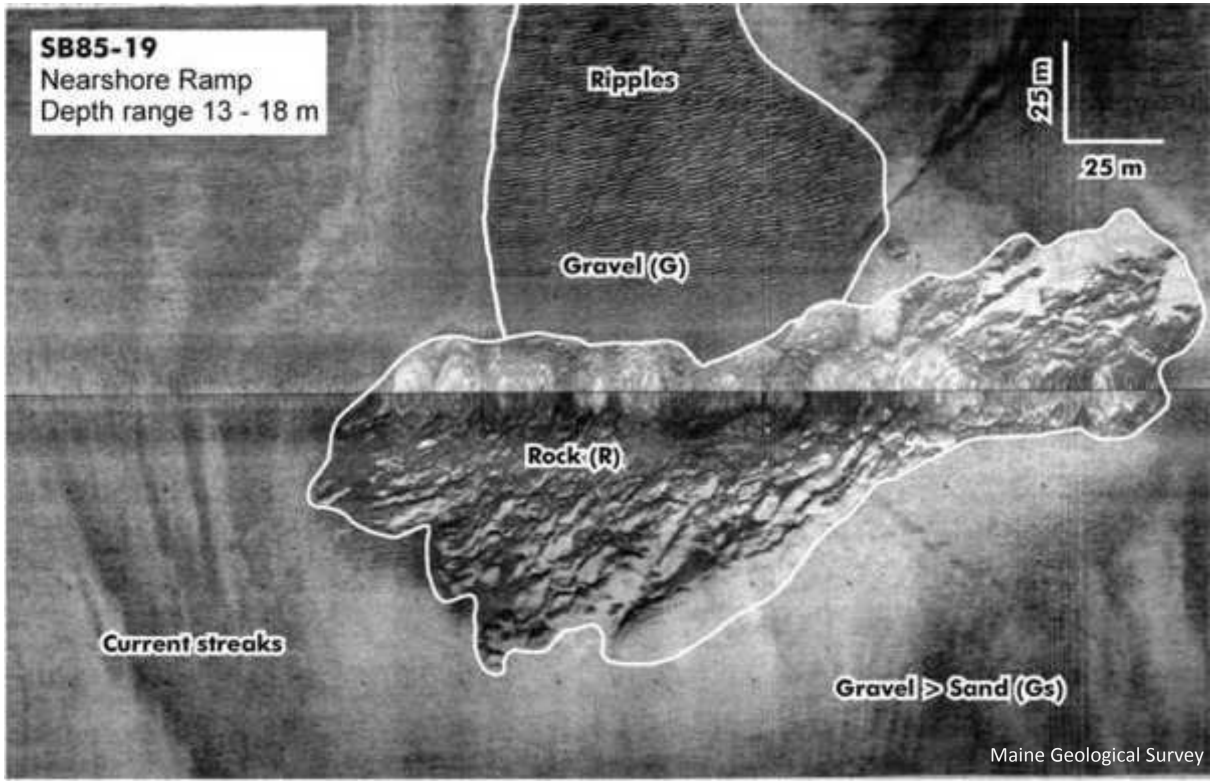


Image from Kelley and others, 1989a

A side-scan sonar image taken offshore of Popham Beach and the Kennebec River mouth in mid-coast Maine provides an underwater view of complex spatial patterns of bedrock, sand, and gravel. The type of seafloor, and consequently marine habitats, can change quickly over short distances. The image, much like an air photo over dry land, is analyzed by geologists to map the seafloor and interpret coastal processes. Wave-formed ripples and current streaks demonstrate sorting of sediment by grain size through combined wave and current action to depths in excess of 50 feet below the sea surface. About 12% of the inner continental shelf of Maine has gravel on the seafloor.

Outer Basin

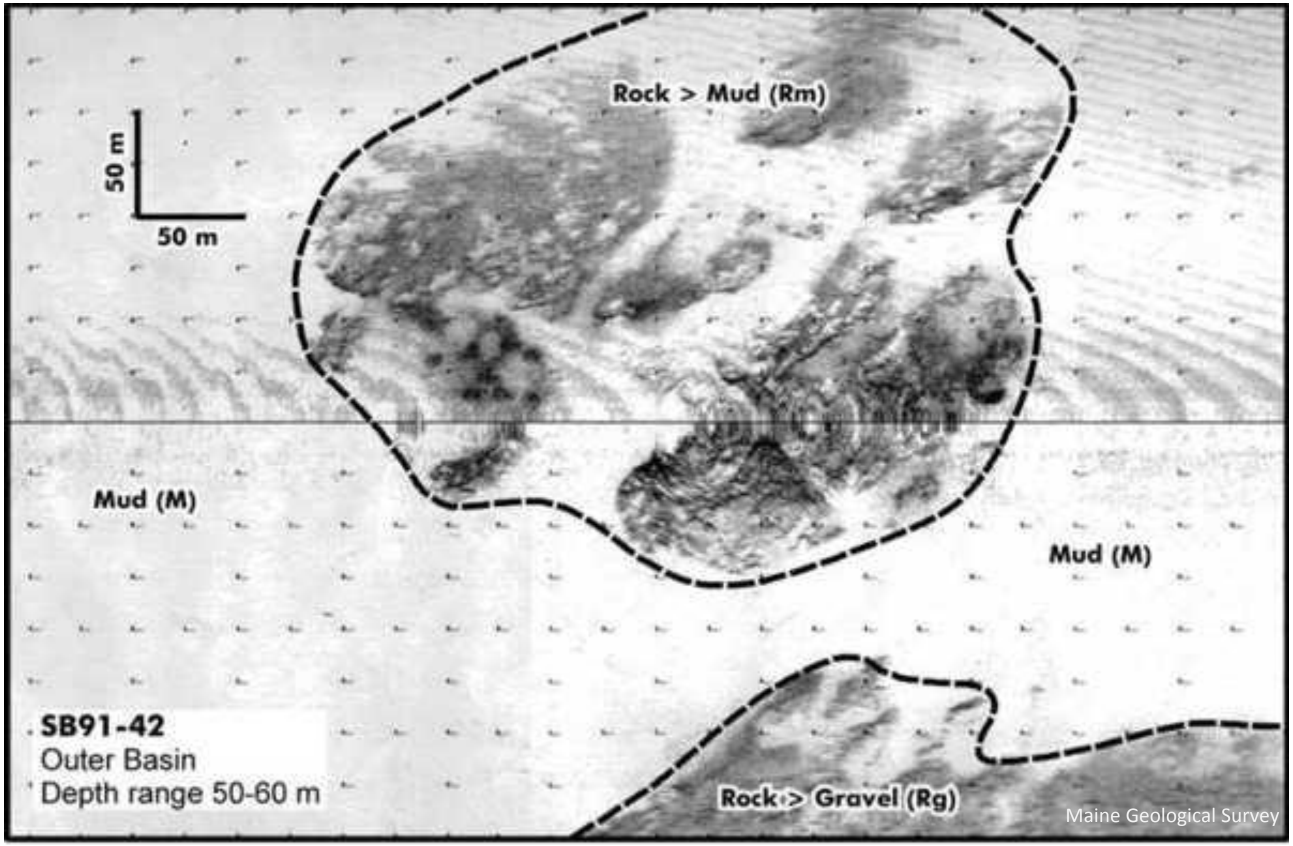


Image from Kelley and Belknap, 1991

This interpreted side-scan sonar image from deep water off Muscongus Bay (mid-coast Maine) shows a patchwork of mud and bedrock on the sea bed. About 41% of the seafloor of the Maine inner continental shelf is rock while 39% is mud. These two seafloor types form a patchwork of soft- and hard-bottom habitats that dominate the western Gulf of Maine. Mud is slowly accumulating in this deep-water setting and burying the rocks.

Rock Outcrop

Image from Kelley and others, 1998

An underwater photograph of a rock outcrop topped with boulders near Toms Rock (offshore of the Kennebec River mouth). In this close-up view, even the rocky seafloor is covered by fine-grained sediments and organisms. Sea anemones, starfish, and lobsters are among some of the marine life that inhabits this rocky and cobbly seafloor.

Muddy Seafloor

Image from Kelley and others, 1998

An underwater photograph of muddy seafloor in Casco Bay (east of Portland). The sediment has a very high water content and is very soft. Worms burrow into the mud to live and physically mix it while grazing. These actions leave the seafloor lumpy with the appearance of small craters. As animals burrow into the mud they mix water and oxygen into the sediment creating microhabitats for other fauna. It takes very little wave or current energy to resuspend mud into the water column. Two scallop shells lie on the surface.

Pockmarks

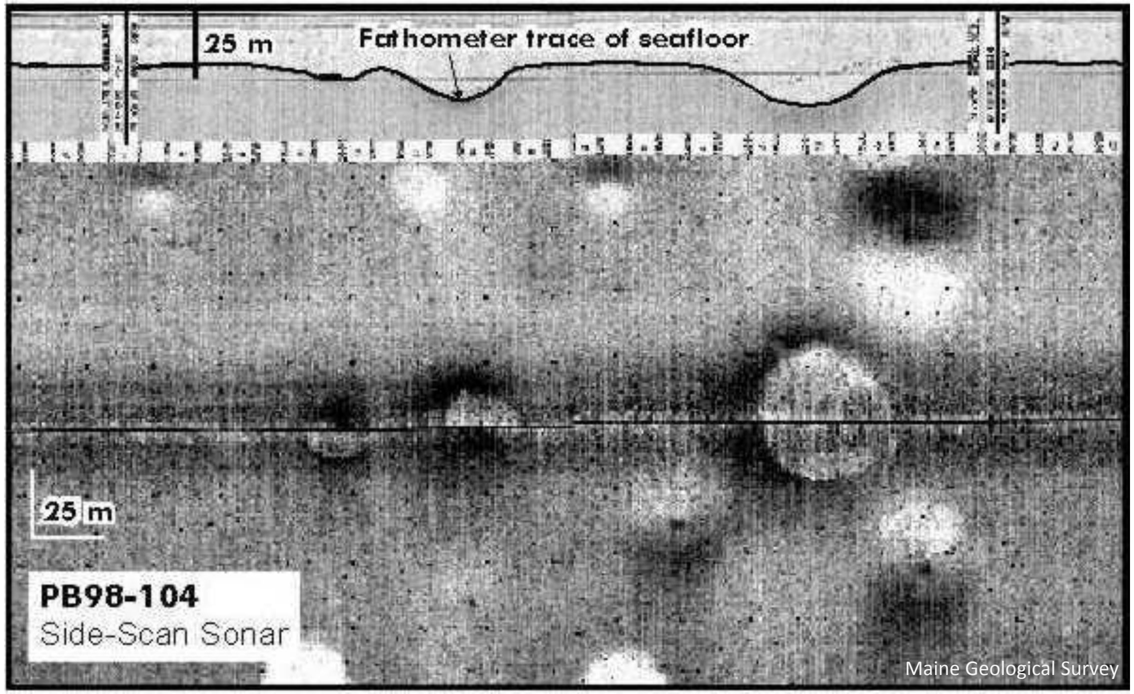
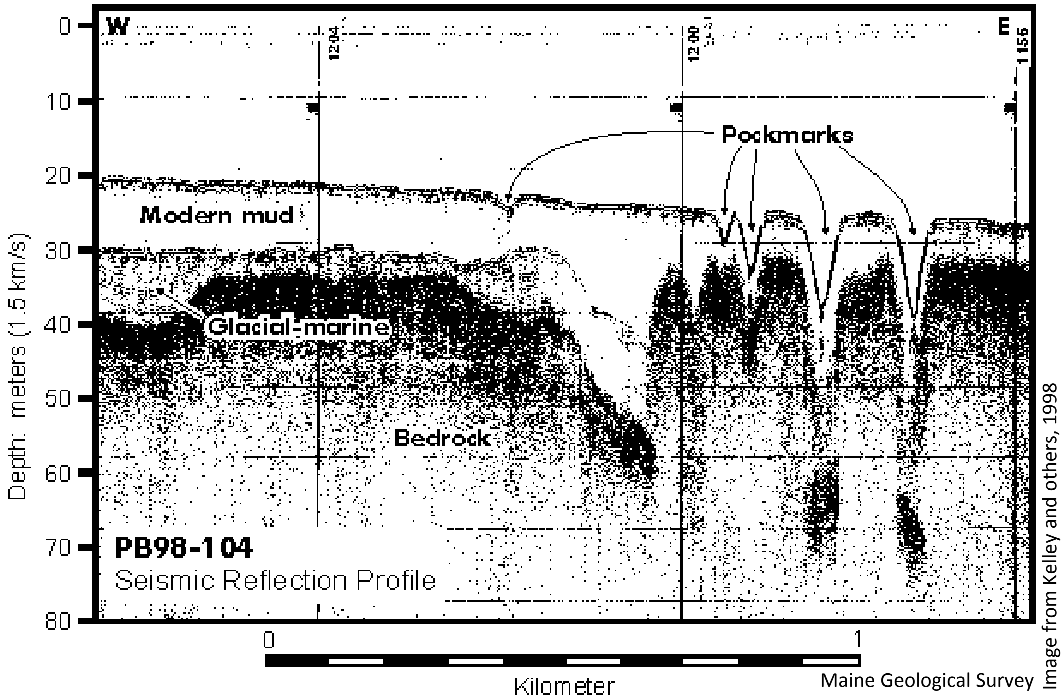


Image from Kelley and others, 1998

A side-scan sonar image (lower portion) with a trace of the water depth (top panel) over an area of Belfast Bay in northwestern Penobscot Bay. The circular features are bowl-shaped depressions called pockmarks. There are several thousand pockmarks in muddy bays along the Maine coast. The densest concentration is in Belfast Bay where almost half of the seafloor is irregular due to the presence of pockmarks. Biogenic gas, mostly methane, is produced by bacteria degrading organic matter in the sediments beneath the seafloor. As the gas concentrations in pore spaces of the mud rise, bubbles form and then can be released upward into the water column. Gas release is accompanied by sediment dispersal and the formation of a depression. Gas escape is probably episodic and ongoing. There have been eye-witness accounts of bubbles rising to the sea surface in this area.

Pockmarks



A vertical transect through the water and sediments shows the buried sediments and bedrock structure in the Belfast Bay pockmark field. This seismic reflection profile is made by bouncing sound waves off the bottom and subsurface geology. Due to the (left-right) compression of the data, slopes are exaggerated and the side walls of pockmarks appear steeper than they really are. The black bands between the pockmarks and just below the surface are generated by gas in the sediments. Gas prevents sound from bouncing off deeper geological layers so the subbottom geology (bedrock) is masked from view in the vicinity of the pockmarks. Modern muddy, and organic-rich sediments appear to contain the gas. Deeper glacial-marine sediments probably contain less organic matter. At the upper boundary of the glacial-marine sediments, there may be an accumulation of organics from postglacial tundra and lakes that have been drowned by sea-level rise over the last 10,000 years.

Sandy Seafloor

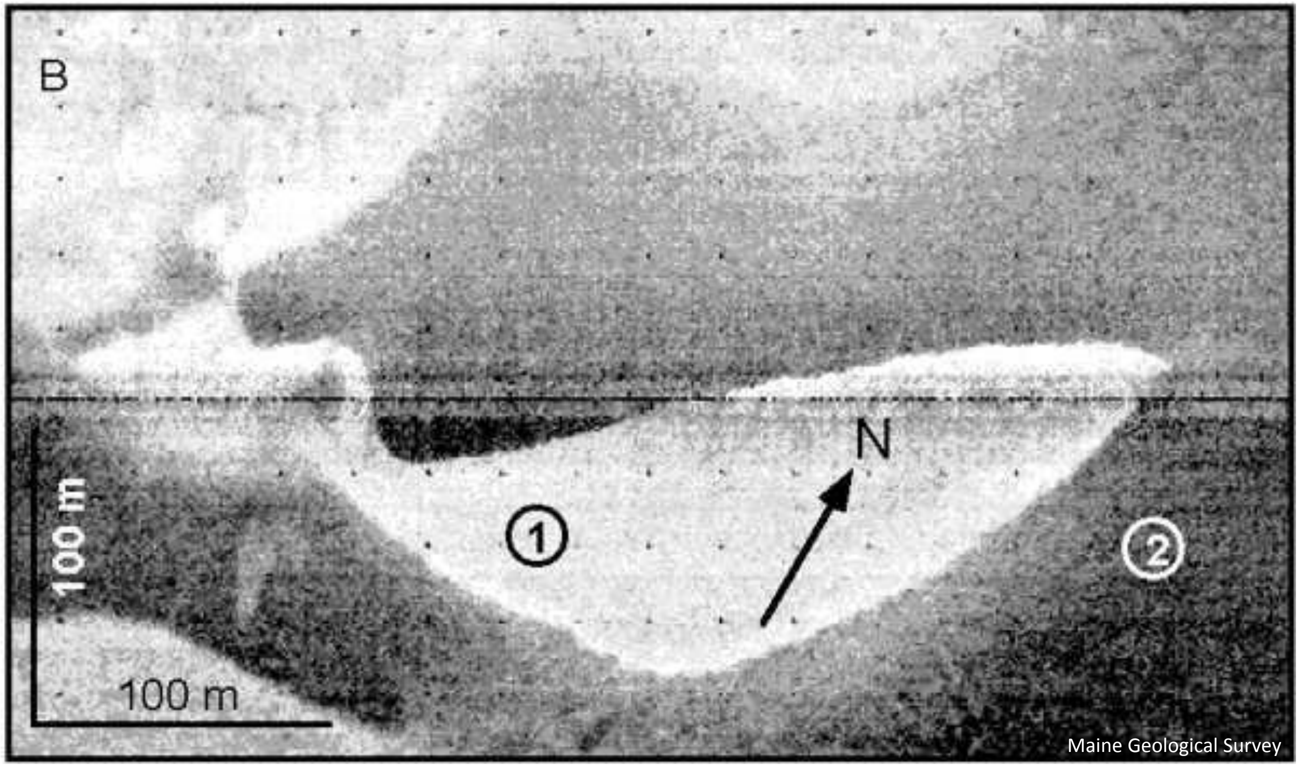


Image from Dickson, 1999

A side-scan sonar image offshore of Seawall and Popham Beaches (mid-coast Maine) shows the surface of the ancestral Kennebec River delta. This paleodelta is relatively smooth on the surface and continually reworked by winter storm waves. Sorting of sediments by waves and currents results in the concentration of fine sand (1) in the form of sand waves. In coarser pea-sized gravel (2), there are ripples created and reworked by ocean swells even to water depths of 100 feet as in this example. Repeated side-scan sonar surveys of this area over a decade have shown that the overall structure of the sand waves, including this one nicknamed The Whale, has been very stable. About 8% of the Maine inner continental shelf is sandy.

Marine Stratigraphy

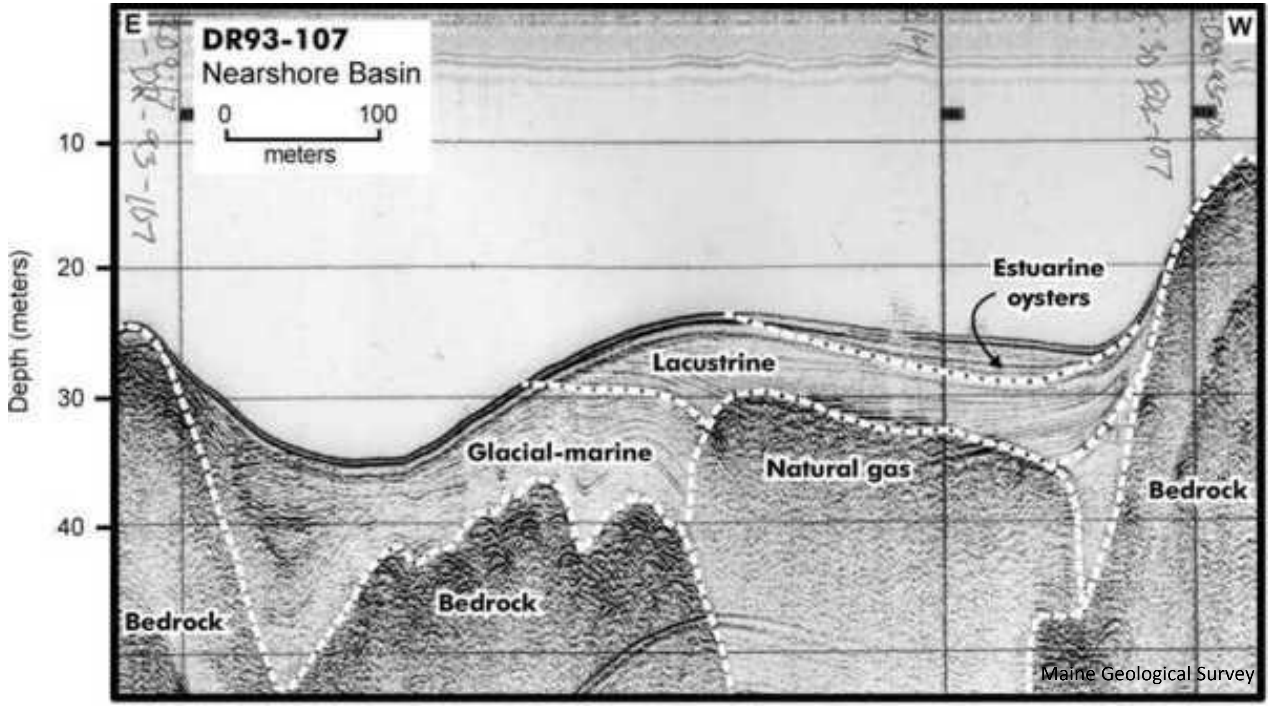


Image modified from Hannum, 1997

This is a seismic reflection profile across the Damariscotta River estuary. As in most Maine estuaries, bedrock frames this geological section. Glacial-marine mud is exposed and eroding on the sea bed in some locations (left). Following postglacial deposition of the marine sediment, sea level fell and a lake occupied the fluvial basin. Consequently, lacustrine mud overlies the glacial-marine sediment in some places (center). Upon subsequent drowning by the sea, an oyster bed covered the former lake (right) and relict estuarine sediments are at the surface. Natural gas (methane) may have formed from microbial decomposition of a lake or bog deposit. It is notable that no "modern" sediment is accumulating in this area of general sea-floor erosion. The geological layers or stratigraphy seen clearly in this record are not always present in other estuaries. The vertical and horizontal scales are different so slopes are exaggerated.

Mud Flats

Of all the intertial environments along the Maine coast, mud flats cover the most area. Based on MGS Coastal Marine Environments maps, 41% of the intertidal zone is composed of mud flats. This flat is along the banks of the Presumpscot River adjacent to Interstate 295 just north of Portland's Back Cove. The higher margins of mud flats are often fringed by salt marshes up to the maximum level of the tides. This flat has a clearly defined dendritic drainage pattern that is exposed when the tide is low.

Salt Marshes

Salt marshes are a very significant intertidal environment along the Maine coast. Based on MGS Coastal Marine Environments maps, 14% of the intertidal zone is composed of salt marshes. These marshes are found behind coastal beach and dune systems (back-barrier marshes) and along the flanks of estuaries and sheltered embayments (fringing marshes). Marshes can be divided into two types: high marsh (dominated by *Spartina patens*) and low marsh (dominated by *Spartina alterniflora*) plant communities. The low marsh is flooded daily by the tides while the high marsh is only fully flooded during more extreme tides that occur several days each month. This Phippsburg back-barrier marsh has a linear master channel and a sinuous secondary drainage. The narrow linear channels (lower left) are ditches dug decades ago to drain the marsh in order to control mosquitoes. The small circular water bodies are called salt pannes and hold water even when the tide is low.

Rock Environments

Photo courtesy of J.T. Kelley

Maine is best known for its rocky coast with bold cliffs, ragged shorelines, and exposed bedrock far above the high tide line. Large swells from storms in the Gulf of Maine surge high onto the exposed rocky coast and remove soil and vegetation far from the normal reach of tides. Based on MGS Coastal Marine Environments maps, 25% of the intertidal zone is rocky. Most of the rocky shores are found along the outer portions of the shore where wave action is the highest. Rocky shores are less common in the interior and sheltered margins of the large bays and estuaries. The rocky intertidal zone is home to a diverse ecology of hardy organisms such as barnacles and periwinkles and surf-tolerant algae. The vertical zonation of organisms through the intertidal zone darkens the rock cliffs in this picture.

Coastal Bluffs

Coastal bluffs composed of sediment are found along about half of the Maine coast. Most bluffs form in sedimentary deposits of glaciomarine mud. Bluffs are most common along the banks of bays and river estuaries that are sheltered from large ocean waves. The toe or base of a bluff is often the top of the intertidal zone, at or just above the mean high tide line. The top of a bluff can be a few feet to over 40 feet above the high tide line. Some bluffs can be unstable and erode a foot or more per year. Bluff erosion can be episodic with some land loss one year and none the next. Over several years or more the top of a bluff will move landward at about the same rate as the toe. Sediment and vegetation eroded from a bluff becomes part of the intertidal zone. This introduction of sediment helps the tidal flats and salt marshes maintain their position as the sea level and tides rise.

Coastal Bluffs

Some coastal bluffs are composed of coarse-grained sediments. These sand and gravel bluffs form steep banks that often rise above a mixed sand and gravel beach. Sediment in these bluffs was deposited beneath or in front of glaciers as they melted back at the end of the last ice age. Sediment supplied to the intertidal zone by coarse-grained bluff erosion often produces a fringing beach. Both toe erosion from waves and tides as well as ground-water and surface water runoff can contribute to bluff erosion and coastal recession.

Rockland Before Landslide

Photo by the James W. Sewall Co.

This vertical air photo taken October 4, 1992 shows the north shore of Rockland Harbor prior to a landslide in 1996. The shoreline is arcuate with small bays anchored by rocky shoals that protrude into the intertidal zone. A high coastal bluff fringes the shore and is covered by a mature stand of trees and shrubs. Three houses (marked by letters) are on level ground above and landward of the top of the coastal bluff. Compare this photo to the next slide to see the extent of land displaced by a coastal landslide.

Rockland After Landslide

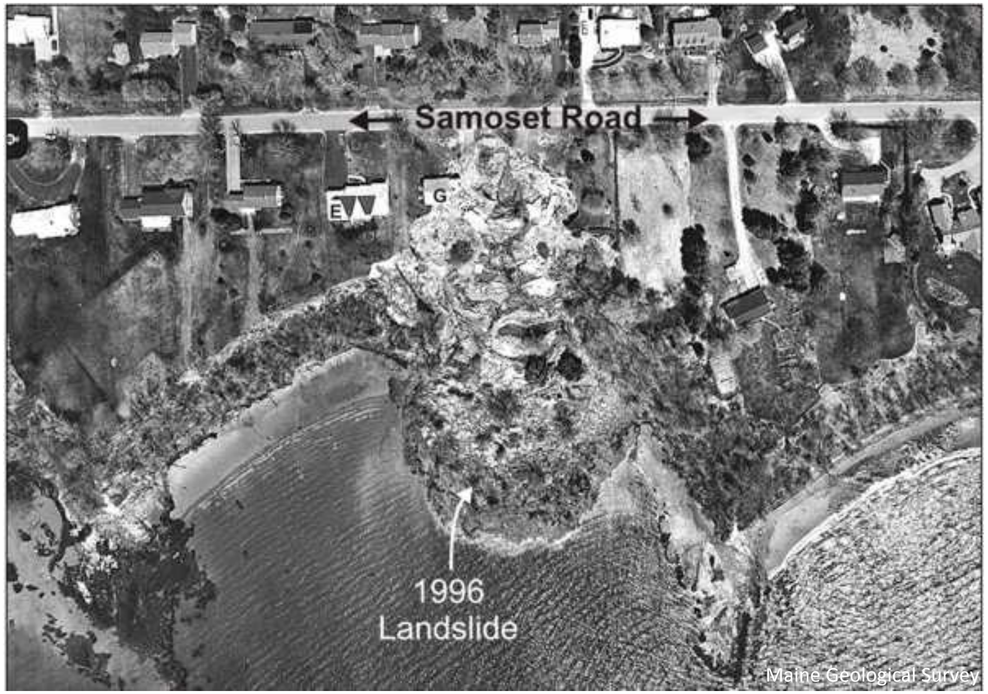
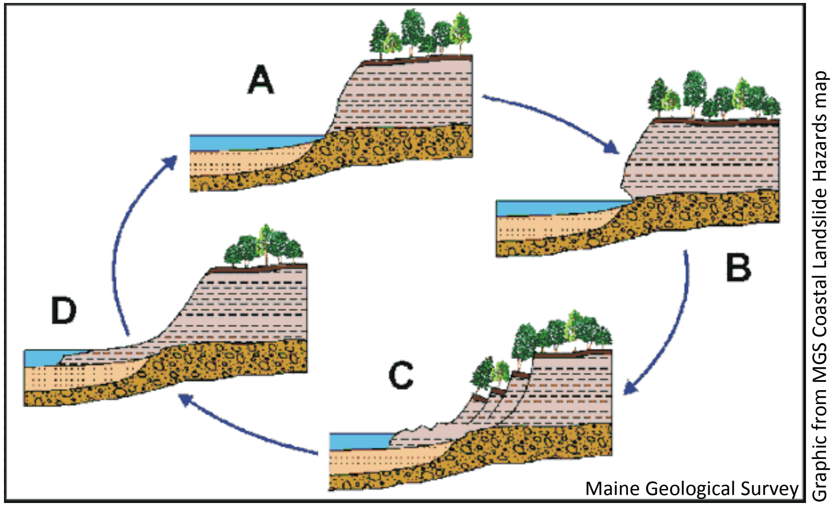


Photo by the James W. Sewall Co.

A vertical air photograph taken May 8, 1996 following a landslide on April 16, 1996 along the north shore of Rockland Harbor. The landslide failure took place primarily over a three-hour period in the night. A series of blocks slid out onto the intertidal zone in a retrogressive failure until the material at the base of the slide was sufficiently high to support the remaining bluff. This slide occurred in a section of glaciomarine mud that was 50 feet or more in thickness and saturated with a high water table. About 0.6 acres of upland were affected. The landslide caused the top of the bluff to recede inland about 130 feet. About 210 feet along the shoreline was affected. The sediment deposited in the slide area covered 3.5 acres. Two homes were destroyed, but no lives were lost. Many coastal landslides occur in spring due to the thawing of the ground and ample water saturating the sediments.

Bluff Erosion Cycle



Bluff erosion and land loss tends to be episodic. Eroding bluffs tend to follow a cycle of toe erosion (A to B), with sediment removed by waves, coastal flooding, and tidal action. Toe erosion can lead to minor slumps and soil loss across the surface of the seaward face of the bluff. Prolonged undercutting can lead to internal movement underground (B to C) which results in a landslide. Landslides involve the internal failure of a thick sequence of sediments that lack sufficient strength to rise above the sea. Some landslides are small and involve a single block and others can involve a sequence of blocks that slide and rotate on several curved planes of failure (black lines in C). Sediment that moves out across the intertidal zone leaves an uneven surface, often covered with terrestrial vegetation, that subsequently comes under wave and tidal scour (C to D). The landslide toe can be gradually eroded over years to decades as sediment is washed away and deposited in other tidal flats or below the low tide line (D to A). Depending on the scale of the mass movement and the strength of coastal processes, the cycle can take years to be completed. Sometimes shorelines adjacent to landslides become more unstable after a landslide has occurred nearby. So shoreline instability may propagate along the coast after a landslide.

Coastal Sand Dunes

Coastal sand dunes are relatively rare along the Maine coast. There are about 2000 acres of sand dunes adjacent to about 30 miles of large sand beaches. These coastal sand dunes are concentrated along the southwestern Maine coast from York to Cape Elizabeth and from Phippsburg to Georgetown in the mid-coast. Other sand dunes tend to occur in isolated areas along the coast. About one quarter of the dune area is taken up by the frontal dune or seaward-most ridge of sand. The frontal dune is commonly 150 feet wide (inland from the beach) and subject to flooding and erosion in coastal storms. Back dunes make up about three quarters of the acreage and the topography is generally lower and hummocky. Back dunes tend to be a mix of open patches (blow outs), low grass and shrub communities, and maritime forests dominated by pitch pine trees. True barrier beach and dune sysems often front tidal marshes and channels filled with sand bars. This photo of Phippsburg shows Seawall (Small Point) Beach in the foreground and Popham Beach in the background.

Surf and Longshore Drift

MGS file photo by S.M. Dickson

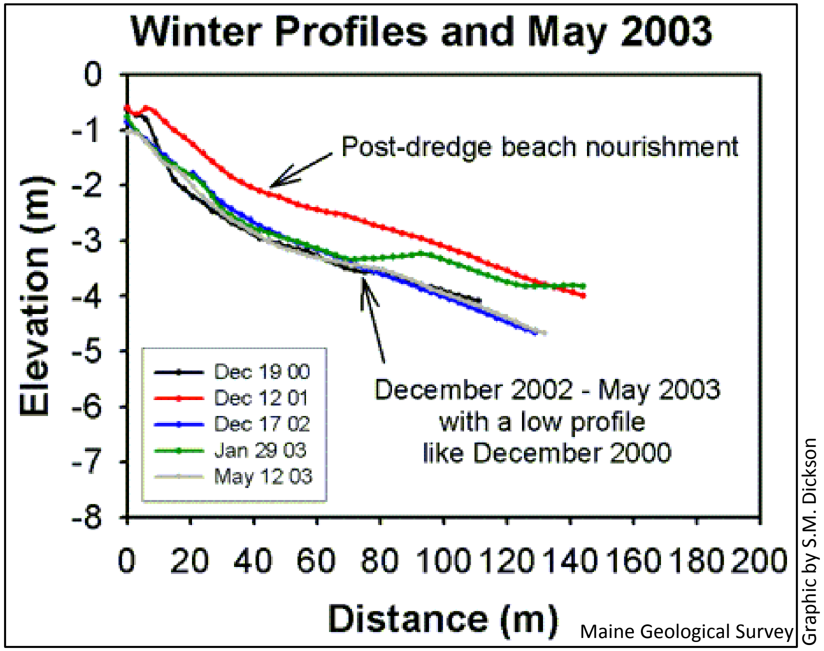
Surf along the beach moves sand both onshore and offshore as well as along the coast. When waves break at an angle along the beach, sand is moved along the shoreline. In this photo of Mile Beach at Reid State Park in Georgetown, the surf is creating a current that moves sand to the right. This sand movement is called longshore drift and it can be reversed by waves that approach the beach from different directions. The highest surf tends to occur in the winter with storms in the Gulf of Maine. Such northeasters can lower the entire recreational beach profile by three feet in a single storm. Sand that erodes in storms tends to move offshore temporarily and then return to build a wider beach in summer.

Frontal Dune

MGS file photo by S.M. Dickson

The frontal dune is a ridge of sand just landward of the beach. The dune ridge is usually covered with American beach grass and a variety of other salt-tolerant vegetation. In a healthy dune, the ridge crest elevation is close to the height to which 100-year storm waves come ashore. The frontal dune is very dynamic and can be eroded 10 to 20 feet or more in a single storm. Sand removed from the frontal dune is carried by waves out on to the beach profile to create a shallow slope or offshore sand bars. This modified beach profile then results in storm waves breaking farther offshore which, in turn, helps prevent more dune destruction. Dunes can recover lost sand over the summer, or in the event of a major coastal storm, recovery may take several years.

Beach Profiles



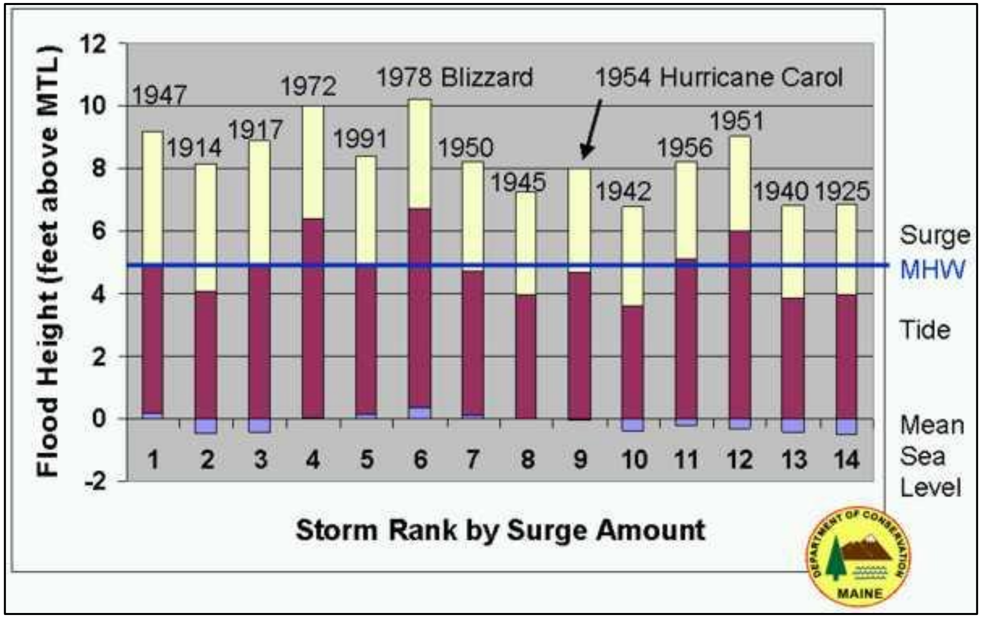
Beach profiles measure the elevation of the dune and beach. Repeated profile measurements over time show how the beach changes from season to season or year to year. In this example, winter profiles from December 2000 to January 2003 are compared. The highest profile, December 2001, measured the beach after sand was pumped onto Wells Beach from a U.S. Army Corps of Engineers dredging project of the Webhannet River and Wells Harbor anchorage. Originally the beach nourishment raised the beach about 3 feet (one meter) but the sand moved off the profile within a year and the elevation returned to the pre-nourishment shape by December 2002. Note that the vertical and horizontal scales are different so the beach slope appears steeper than it actually is. The length of the profile lines is the distance from the edge of the sand dune (left) down to the low tide line (right). Data were collected for the State of Maine Beach Profiling Project by a team of volunteers using the Emery profiling method.

Back Dune

MGS file photo by S.M. Dickson

The back dune environment has low-relief dunes with patchy vegetation and wind-blown sand. Some back dunes have a pitch pine forest. About one-third of Maine's back dunes are lower than the 100-year floodplain elevation and subject to coastal flooding during large storms. In a natural setting, back dunes are protected from ocean surf by a higher frontal dune ridge.

Coastal Storm Flooding



Graphic by by S.M. Dickson, MGS

The severity of coastal flooding depends on the height of storm surge (yellow), tides (dark red), and sea level (blue). In this bar graph, the 1947 storm surge was the highest on record (Rank 1) but it occurred during a mean tide (Mean High Water, MHW) so flooding only reached about 9 feet above the Mid-Tide Level (MTL). The largest coastal flooding event in recent decades was the 1978 Blizzard. This storm had a surge of about 3.5 feet but it coincided with an extreme (spring) tide and when mean sea level was slightly above the mean (blue). The combined factors of sea level, tide range, and storm surge all affect the amount of coastal flooding. Hurricane Bob (1991) and Carol (1954) had surges over 3 feet but the tides were not extreme during landfall. Coastal property damage and erosion are affected by the flood level, waves, and duration of the storm. A slowly moving storm in the Gulf of Maine will produce the most surge and highest waves. The phase of the moon is the most important variable determining the height of the tides. Highest tides generally occur during new or full phases of the moon.

Dune Scarp Formation

MGS file photo by by S.M. Dickson, 12/13/92

In December 1992 an extratropical low pressure center stalled in the Gulf of Maine for four days. This December 1992 Northeaster resulted in a coastal storm surge of less than 2 feet, but the fact that the surge continued over about 8 high tide cycles resulted in some severe beach and frontal dune erosion. This photograph shows Seawall Beach from the vantage of Small Point (looking northeast toward the Kennebec River) in mid-coast Maine. The higher surge allowed the surf to run up the beach profile and directly into the dunes.

Dune Scarp Formation

MGS file photo by by S.M. Dickson, 1/24/92

Frontal dune erosion occurs mostly in the winter during Northeasters. Waves cut into the sand and vegetation of the frontal dune and sometimes leave a vertical face or scarp at the edge of the dune. The beach can be 3 to 5 feet lower than the dune at the scarp. During periods between winter storms some sand can return ashore to the edge of the dune and begin to make the scarp smaller. Over the summer, more sand will return to the upper beach profile and toe of the dune. This natural offshore-onshore exchange of sand rebuilds what was lost during the winter and prepares the frontal dune for another storm season. American beach grass will send roots (rhizomes) seaward in spring and new growth will help trap sand and lead to frontal dune rebuilding. A scarp the size of this one at Seawall Beach in Phippsburg may take more than one year to heal and return to its original size. Some frontal dune ridges in Maine have former scarps embedded on the seaward slope of the frontal dune ridge.

Frontal Dune Overwash

MGS file photo by by S.M. Dickson

Some storms do not erode the frontal dune and produce a scarp (as seen in the previous picture). Depending on the shape of the beach profile and storm waves, sand can be carried up and onto the frontal dune. In fact this process of frontal dune flooding with water laden with sand is the primary way the frontal dune ridge is built. Waves run up the seaward slope of the frontal dune, lose speed as water soaks into the dune, and deposit sand. Some waves may be large enough to overtop the ridge crest and deposit sand on the landward slope (as shown in this photo). The process of overwash leads to layers of sand building up the height of the frontal dune and adding more sand volume to the entire ridge. This build-up of sand is an excellent process for the storage of sand that can then be released to the beach in other storms that have damaging waves that cut a scarp into the frontal dune. The sand deposit, called washover, in this picture was made by the October 1991 Perfect Storm at Pine Point Beach in Scarborough. American beach grass easily recovers from being buried and spring growth will return to hold and trap more sand. Over time, the elevation of the frontal dune ridge will be the result of buildup by washover and lowering by scarp formation. Secondarily, the dune ridge is modified by loss or gain of wind-blown sand.

Frontal Dune Overwash

Flooding over the frontal dune ridge crest can be dramatic. The force of even shallow waves can impact and alter development in the dunes. In this photo, overwash from the October 1991 Perfect Storm carried segments of a wooden footpath down the back slope of the frontal dune. This dune walkover at Ferry Beach State Park in Saco was not anchored to the ground and had less of an impact on the dune than would a rigid structure that was fixed in place. When waves impact a fixed structure there can be more scour and erosion of frontal dune sand which, in turn, lowers the dune and allows subsequent waves to travel farther across the dune with more force.

Beach and Dune Migration

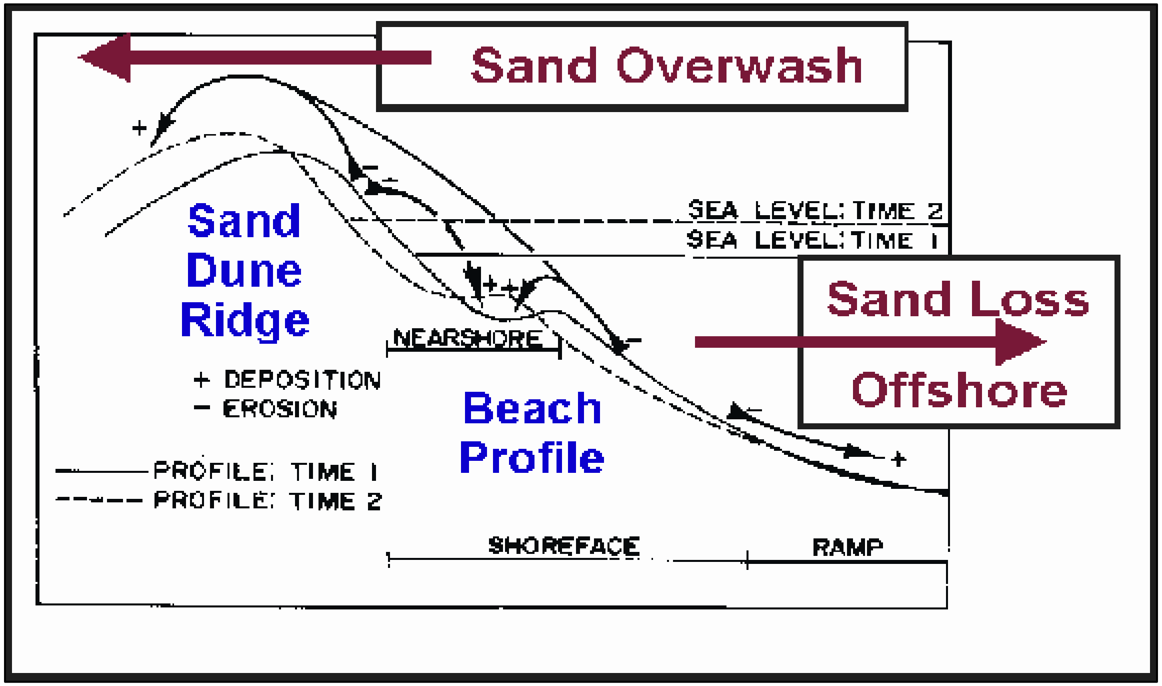


Figure from J. T. Wells, 1995 and after Dubois, 1992.

Sand on the beach profile and in the dunes can be transported both offshore and onshore as seen in the previous pictures. On time scales of decades to centuries, the elevation of the sea also influences these processes. If sand is conserved in this beach-dune system over time, then as the sea rises (Time 1 to Time 2) the landform will migrate up and inland keeping its shape. If sand is not conserved and lost offshore due to net deposition of sand in deeper water, then the dune ridge will flood with greater frequency because the sea, and hence the coastal floodplain, are relatively higher. Another important consideration in the longevity of the beach and dune landform is the importance of sand transport along the shoreline (not shown here but described in slide 22.) The cross-sectional area of the system can either gain or lose sand that is carried into or away from the beach profile by longshore drift.

Drowned Forest

MGS file photo by by S.M. Dickson

One of the signs of movement of the beach and dune system is the presence of tree stumps exposed on the beach. This stump (to the left of the photographer) has survived in a place it once grew when sea level was lower. Its age, based on others in the region, is between 2,000 and 3,000 years old. In the last 3,000 years sea level has risen along the southern Maine coast about 6 feet, or about the same height the trees on shore are now above the stump. The stump was once part of a wooded upland that was inland of Middle Beach in Kennebunk (shown here). As sea level rose over the last few millennia, the coastline and beach and dune system moved up and over the terrestrial environment. Continued landward migration of the dune moved over the stump and left it exposed on the beach. A series of northeaster storms in May 2005 uprooted the stump and it became driftwood.

Drowned Salt Marsh

MGS file photo by by S.M. Dickson

The remnants of a drowned salt marsh are exposed nearly every spring at Laudholm Beach in Wells. Thick salt marsh peat deposits (brown material next to the cobbles) are being eroded by winter storms. The peat was once part of the back-barrier salt marsh system behind the dunes. Today, a similar peat is forming at a higher elevation behind the maritime forest (background). The peat in this picture was buried by dune migration and the overwash process (slide 31) as the entire coastal sand dune system migrated inland during 2000 years of sea-level rise. Assuming the former coastal dune system was the same width as it is today (500 feet) then the rate of shoreline recession was on the order of 0.25 feet per year. Beneath the peat are glacial sediments including cobbles and sand that are reworked across the beach profile and even piled onto the frontal dune by waves. In summer and fall, the beach is much more sandy due to the seasonal onshore migration of sand.

Jetty and Breakwater

MGS file photo by by S.M. Dickson

The dynamic shifting of tidal inlets and sand bars at the mouths of many sandy rivers in Maine led to construction of coastal engineering structures to maintain channels for navigation and to act as breakwaters for boats moored in the estuaries. The north jetty of the Saco River (left) was built by the U.S. Army Corps of Engineers and it has been in place since the 1860s. Over decades since installation, this and other jetties, have altered the balance of sand on adjacent coastal beaches. Some dunes next to jetties have eroded (as in this Saco location of Camp Ellis) and others have gained sand (such as Pine Point in Scarborough). This jetty, over 6,000 feet long, also inhibits sand from leaving the Saco River and reaching the beach at Camp Ellis. Other federal jetties are at sandy tidal inlets in Scarborough, Kennebunk, and Wells.

Seawall

MGS file photo by by S.M. Dickson

Shorelines have been armored along some Maine beaches in response to short-term erosion events from a series of bad winter storms or due to chronic erosion that continues to move the shoreline inland. In this picture, riprap (boulders) were placed on the frontal dune scarp at Goose Rocks Beach in Kennebunkport. This practice is no longer allowed on beaches in Maine, except as an emergency and temporary measure. Seawalls and riprap tend to reflect waves back onto the beach and result in a lower beach profile. The vertical change in the beach elevation, seen here by steps that no longer reach the beach, can be a result of seawalls preventing the sand from naturally migrating onshore and filling a dune scarp (slides 28 and 29). Vertical changes in the beach elevation may also be due to seasonality in the beach profile so some of the gap between the last step and the beach may be less in summer than in winter.

Seawall and Wave Reflection

MGS file photo by by S.M. Dickson

Seawalls stop waves from running up and onto the frontal dune. Waves that impact the wall lose some energy by reflecting a smaller wave back out across the beach profile and by sending sand and spray vertically. The backwash from wave impacts can scour the beach in front of a wall and lead to sand moving either offshore or alongshore. The wooden seawall (foreground) and the two shuttered houses in the background were all destroyed by waves in Camp Ellis Beach (Saco) since this photo was taken in 1986. The shoreline recession rate (land loss) along this section of beach near the jetty (slide 34) has been on the order of 2 to 3 feet per year.

Seawall Damage

MGS file photo by by S.M. Dickson

Wave forces impacting seawalls are enormous. This seawall at Moody Beach in Wells was damaged by wave action in 1987 despite the fact that it was made of concrete, reinforced with rebar, and backed by boulders. Wall failure is commonly followed by loss of land (soil, sand, fill) from behind the wall before the storm abates. The form and function of this frontal dune is masked by a high density of development and land alteration.

Seawall Damage

MGS file photo by by S.M. Dickson

When a seawall fails, dune sand, fill, and topsoil can be rapidly released from behind the wall. Scour by storm waves continues to erode both vertically and horizontally very quickly. The cement and block foundation of this Saco home was destroyed by waves from the 1991 Perfect Storm.

Recreation

MGS file photo by by S.M. Dickson

Not all beaches in Maine are eroding, but many are. Continued beach erosion reduces the width of the recreational beach, particularly when dunes are fixed in place beneath frontal dune homes, and seawalls do not let the dune and beach maintain their natural shape and migrate inland. Erosion in Wells (above) has limited the optimal time for recreation to about half of the tidal cycle. Beaches and dunes are important as a protective barrier against storms and coastal flooding as well as a significant part of Maine's tourist economy.